INVESTIGATION OF CLOUD PROPERTIES AND ATMOSPHERIC PROFILES WITH MODIS

QUARTERLY REPORT FOR JAN-MAR 1997

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ABSTRACT

The WINter Cloud Experiment (WINCE) was directed and supported by personnel from the University of Wisconsin in January and February. Data sets collected by the MODIS Airborne Simulator (MAS) and other instruments on the NASA ER2 will be used to develop and validate cloud detection and cloud property retrievals over winter scenes (especially over snow). The data sets exhibit good quality; a few examples are shown. Software development focused on utilities needed for all of the UW product executables in preparation for the June 1997 Version 2 deliveries. MAS calibration for the data flights during SUCCESS neared completion. A significant effort was made, in cooperation with SBRS and MCST, in characterizing MODIS PFM thermal infrared performance.

TASK OBJECTIVES

Software Development

The five UW science production software packages (cloud mask, cloud top properties, cloud phase, atmospheric profiles, and ancillary data) continue to evolve. Science algorithms are being tested with MAS data from both the SUCCESS and WINCE experiments. In preparation for the Version 2 deliveries, common utilities needed for processing in the DAAC environment are being developed for use with all science production software packages.

MODIS Infrared Calibration

UW is working closely with SBRS and MCST in characterizing MODIS thermal infrared calibration. Paul Menzel, Dan LaPorte and Chris Moeller participated in the MODIS Thermal Infrared Calibration Team Meeting in January at the University of Miami. Progress has been made. Dan LaPorte was chosen as a Science Team Representative to work with the MODIS engineering team during the thermal vacuum calibration of the PFM.

WORK ACCOMPLISHED

MODIS Software Development

UW MODIS programmers have been meeting every two weeks to discuss coding progress and to divide up common tasks to prevent duplication of effort. Some jobs have already been completed. Version 1 algorithm codes were retrieved from SDST configuration management at GSFC and recompiled at the UW SCF. Walter Wolf set up a Revision Control System (RCS) for MODIS production software. All source text files were checked into RCS. The RCS directories contain an archive of all of the changes that will be made for the V2 MODIS production code. In the process, RCS ID's have been included in the V2 MODIS production code such that each executable contains information of the versions of all the subroutines used to create that executable.

Utilities to create the UW MODIS product output HDF files are being developed. This requires several steps. First, a C program is written to read in the MODIS file specifications in CDL format. Next, the C code takes the file specifications and generates two FORTRAN subroutines which will create the output HDF files during production. These two subroutines contain all of the information needed to create the output HDF files. The advantage to this approach is that it shortens the MODIS code which creates the output HDF product files, and it uses the file specifications as input. This guarantees that the output file will match the specifications.

Other programs currently under development are error and message handling.

Prototype Clear-Sky Brightness Temperature Map

Testing of prototype clear-sky brightness temperature maps for use in the MODIS operational cloud mask was completed using AVHRR Global Area Coverage data from the Atlantic Ocean. Single-pixel, high quality (confidence of unobstructed surface > 95%) clear-sky values of 11 μm brightness temperature were obtained by the AVHRR cloud masking algorithm in ocean regions during daylight hours. These values were incorporated into an eight-day composite equal-area grid at 25 km resolution. The composite file was updated after each day was processed, that is; the clear-sky observations from day one of the previous eight days was eliminated and those from the day just processed were added. Mean, minimum and maximum brightness temperatures were made available to the nighttime algorithm to be used as additional input to the cloud mask. The additional information was found to aid in detection of low-level clouds at night, particularly in the eastern South Atlantic where stratus clouds are very common. A total of 16 days were processed.

Improved Land/Sea Tag File

A new land/sea tag file was obtained and implemented in the AVHRR cloud mask algorithm. The file contains seven categories of surfaces: land, coast, intermittent water, shallow inland water, deep inland water, shallow ocean, and deep ocean. The additional information is useful for identifying discontinuities on the surface which may have an adverse effect on the cloud mask output, such as ocean and lake shorelines and river deltas. Experience gained from using the new file will be incorporated into the MODIS cloud mask production software.

Snow Detection

A surface snow-detection algorithm provided by Bryan Baum of Langley Research Center has been implemented and is being tested in the AVHRR cloud mask. Even though the AVHRR has a limited number of channels for this task, early results have been promising.

Future SCF Hardware and Communications Needs

UW has begun to investigate the communications and hardware needs of our SCF in preparation for the July 1998 MODIS launch. Significant upgrades in both speed of data transfers and computing power are anticipated.

Visualization Software

Two MAS visualization tools were released via the Web to GSFC and ARC.

MASVIEW: http://cimss.ssec.wisc.edu/~gumley/masview/masview.html. MASVIEW displays single bands of full resolution MAS imagery read from any of the following formats (which are identified automatically):

- Exabyte raw format as recorded onboard the aircraft (57344 bytes per block),
- UW Intermediate format created by readtape5.f (74200 bytes per block),
- NASA/GSFC HDF Level 1B format.

Some of the options available in MASVIEW include:

- display counts, radiance (HDF only for bands 1-25), or brightness temperature,
- output in B&W or Color Postscript (user can customize size and orientation),
- flip easily between any number of images (movies!),
- reverse the IR grey scale color table so clouds are bright and land is dark,
- plot HIS FOV locations on MAS image, if HIS data is available,
- save image as GIF,
- display subsets (e.g. scan 1-1500) of large HDF scenes,
- skip every other scanline to compress images vertically.

DISPLAYQUICK: http://cimss.ssec.wisc.edu/~gumley/displayquick/displayquick.html. DISPLAYQUICK displays MAS subsampled quicklook data in a scrolling image window, allowing a user to view an entire flight of data. HIS spectrum locations may be plotted on top of the imagery, and by clicking on the image with the mouse, the nearest HIS spectrum will be plotted. This tool was used for interactive demonstrations (via laptop) at the AIRS Science Team meeting and the AIRS ATBD reviews.

In addition, Liam Gumley has also created a visualization tool for MODIS HDF files. An example of the latest Level 1B simulated data set radiances with a map overlay in shown in Figure 1.

DAO Product Evaluation

An investigation into the quality of DAO temperature and moisture profile analyses are underway. The products will be compared with National Center for Environmental Prediction (NCEP) model forecast outputs. Both profiles will be used as input to the HIRS global cloud climatology operational software; differing results will be closely examined. DAO has agreed to create a daily profiles product in binary form, which can be electronically transferred to the UW. Work has begun on converting the binary grid format into McIDAS grid files.

MODIS Infrared Calibration

The MODIS Thermal Infrared Calibration Team met at the University of Miami on 9-10 January 1997. MODIS instrument performance, delivery and testing schedules were discussed. Bill Barnes reported on MODIS progress and schedules; MODIS will start final thermal vacuum testing late in the first quarter, with instrument delivery for spacecraft integration scheduled for April; launch remains mid 1998. Gerry Godden gave detailed presentations covering performance testing. Good progress has been made by Santa Barbara Remote Systems to achieve detailed characterization of the MODIS system relative spectral response (RSR) functions for the longwave infrared bands used for estimating atmospheric temperature, moisture and cloud properties; Chris Moeller showed evidence that a 5 nm shift of the RSR to longer wavelengths is required for LWIR spectral bands, based on spectral position comparisons between the RSR and forward model data. The MODIS system response versus scan mirror viewing angle remains a concern; further characterization will be requested from MIT/LL but the most useful data will be collected in a space look maneuver after launch. A modest amount of crosstalk remains from the long wave infrared window into the CO2 bands at longer wavelengths; Chris Moeller presented simulations with MAS data showing that the expected crosstalk has significant effect on brightness temperatures that must be corrected. It appears likely that ground corrections to radiances will be necessary for the MODIS on the am platform, but it is hoped that an instrument fix can be arranged for the MODIS on the pm platform. Otis Brown stressed that as much as possible corrections not possible for the PFM should be considered for the FM1, schedule and cost permitting. Harry Montgomery showed that the MODIS algorithm is configured so that the non-linearity coefficient is independent of the instrument temperature and scan mirror reflectivity (so that one determination should be adequate for all instrument temperatures; this needs to be tested with PFM vacuum test data). Paul Menzel presented results showing successful application of the MODIS calibration algorithm to GOES data; the MODIS correctly characterizes the detector voltage as a quadratic function of the incoming radiance (GOES has radiance as a quadratic of detector voltage). Shi-Yue Qiu and Dan Knowles presented the MODIS infrared algorithm details, reviewing the strategy for determining the non-linearity prelaunch and the slope and offset in flight. Also the capabilities for analyzing PFM vacuum test data were demonstrated with EM test data.

The team concurred that considerable progress had been made in the last three months toward characterizing MODIS PFM infrared performance, understanding the best approaches toward ground processing of radiances, and suggesting instrument changes to ameliorate problems on FM1. However some infrared bands remain problematic and much more needs to be done.

Several action items were assigned to UW. They are: (1) UW will work with SBRS and MCST to determine the best RSR for the PC infrared spectral bands (31 through 36). This includes determining which spectral bands are likely to have a 5 nm shift in the RSR. The piece part calculations will be reviewed to converge on the best RSR determinations. It was noted that the band 34 RSR seems out of family and is still puzzling. (2) UW will generate tables using FASCODE to correct for water vapor absorption in the LWIR and MWIR for various configurations of the vacuum test. These have been subsequently delivered to SBRS for on site assistance in interpreting PV RSR test results. UW will assess possible spectral shifts in bands with sufficient absorption features (24, 25, 26, 27, 28, and 30); measurements in ambient as well as thermal vacuum are desirable so that absorption features can be identified. SBRS should be encouraged to sample the spectrum at overlapping intervals with double the spectral resolution (e.g. for band 30 use 15 nm). SBRS has subsequently agreed to this. (3) UW will study the current gain settings for the infrared bands to assure that truncation error is less than NEDR. (4) UW will suggest to NOAA that in order to minimize complications caused by the scan mirror emissivity, a subset of the data near the onboard blackbody angle should be considered. This implies that data at -45 to - 5 degrees from nadir is recommended.

An assessment of spectral position accuracy for MODIS PV band RSR will be made when the RSR data becomes available. Forward model runs (LBLRTM w/HITRAN96 database) indicate that water vapor features near 6.64, 6.78, and 6.86 microns are useful for assessing the spectral position reporting accuracy of the SpMA. In order to assess small (nanometers) spectral position errors, a high sampling rate data set (approximately 1.5nm increment between measurements) will be requested over these spectral regions. MODIS PV RSR are scheduled during T/V in early April.

DATA ANALYSIS

WINCE Field Experiment

The Winter Cloud Experiment (WINCE) data collection phase was completed in February 1997. WINCE is an early effort in a series of planned ER-2 deployments in support of MODIS product development and validation in both the pre-launch and post-launch phases. WINCE was designed to study clouds, snow, and ice in the complex mixed scene (clouds over snow/ice background) conditions of winter environments in support of the algorithm development for MODIS cloud and snow products. A NASA ER-2 aircraft, the primary data collection platform, was deployed from Madison WI from 23 Jan - 13 Feb, 1997. The ER-2, carrying an instrument complement including the MODIS Airborne Simulator (MAS), High-spectral resolution Interferometer Sounder (HIS), Cloud Lidar System (CLS), Microwave Imaging Radiometer (MIR), Tilt Scan CCD Camera (TSCC), and RC-10 camera, flew 10 missions (52 hours) in the 21 day period (Table 1). UW ground based measurements included the UW uplooking HSRL lidar, AERI for atmospheric profiles and constituents, downlooking radiometry of snow surfaces and snow crystal sampling, and classonde balloon launches, As much as possible, these ground based measurements were collected during every ER-2 flight. GOES, TOVS and standard NWS measurements were captured and archived for each day as well as cooperative observer networks for snowfall and depth. The WINCE data set covers many different combinations of cloud and surface conditions and captures simultaneous observations from several other observing systems; it includes thin/thick low/high cloud over snow, ice, water and bare land backgrounds, clear scenes of snow, ice and water surfaces, daytime and nighttime conditions, overpasses of ground-based measurements (snow depth, emissivity, uplooking interferometers and lidar, atmospheric chemistry, classondes), and underpasses of the polar orbiting ADEOS satellite (OCTS, IMG, and POLDER). Many data sequences include transitions from cloudy to clear scenes over uniform snow background (day and night), bare ground to snowcover, and snow to icecover to open water.

Work has begun on prioritizing science data sets for WINCE (Table 2). Highlights of the data collection include:

Date	Flight	Highlights
1/28	97041	clear snow scenes, cirrus over snow, ADEOS underflight
1/29	97042	thin to thick cirrus transition, bare ground to snow transition
1/30	97043	repeat overpasses of water and ice cloud with UW based HSRL
2/2	97044	thin cloud over L. Superior ice, ADEOS underflight
2/6	97045	thin cloud over Hudson Bay ice and ice leads
2/8	97046	clear water over L. Huron, water to lake ice to snow transition
2/9	97047	snow scenes w/Hall ground based measurements
2/10	97048	night flight, thin to thick cirrus transition over snow background
2/12	97049	clear snow scenes over Hall site in WI, ADEOS w/TSCC
2/13	97050	thin cirrus scenes over HSRL, ADEOS underpass.

For example, data scenes over Hudson Bay show thin low cloud over the ice and snow covered bay (Figure 2). This transmissive cloud is difficult to discern in MAS visible imagery (because of bright snow/ice background) and is essentially invisible in the 11 micron window data (the imagery shows dramatic ice leads over the entire region). Strong evidence that the clouds exist is given by cloud shadows on the ice background and by CLS downlooking lidar data from the ER-2 platform. This is an example of WINCE data that will be used to severely challenge and refine the skill of the MODIS cloud mask algorithm. Cloud detection spectral tests using MAS 4 micron data will be tested on this scene. A second example (Figure 3) shows thin cirrus scenes over snow background in North Dakota. The MAS 1.88 micron channel (similar to MODIS 1.38 micron) does a good job of depicting the thin cirrus coverage. Unfortunately, the 1.38 micron data will not be useful at night. Nighttime cirrus scenes over snow and ice are however included in the WINCE data collection and will be investigated for cirrus detection.

A WINCE homepage was created at: http://oldthunder.ssec.wisc.edu/wince/wince.html The homepage includes a daily quicklook archive with flight summaries, flight tracks, quicklook MAS imagery, and interesting data segments.

A modified MAS processing procedure has been instituted for MAS data set dissemination from the GSFC DAAC; it has been streamlined with the intent of speeding up the distribution of these data. The MAS WINCE data set represents the first test of this procedure. Three MAS data flights have been selected as “Golden” days for high priority processing with a preliminary radiometric calibration. Those days are 6 Feb (flt 97-045), 9 Feb (flt 97-047) and 12 Feb (flt 97-049). It is expected that these data sets will become available to WINCE participants and instrument P.I.’s by 1 May, which is less than 3 months after the completion of the WINCE data collection. MAS final calibration assessment for the WINCE data set has begun. A MAS final calibration WINCE data set is planned for release by FY98.

<u>MAS SUCCESS Field Program data set calibration</u>

Final calibration for the MAS SUCCESS data set is well underway. Laboratory spectral measurements collected in March and June 1996 have been reviewed and corrected for the ambient conditions of the Ames Calibration Facility Laboratory. Ambient laboratory atmospheric absorption is estimated using the Line-By-Line-Radiative-Transfer-Model (LBLRTM) with the HITRAN96 database. The high spectral resolution forward model output is convolved with the monochromator system characteristics to produce atmospheric absorption estimates comparable to the atmospheric absorption observed in the MAS spectral response function (SRF) measurements. Using several well-defined spectral features, the monochromator spectral position reporting accuracy is also assessed. This assessment is based on a comparison of absorption feature shape as given in the MAS output and the convolved forward model data. It is observed that small spectral shifts in the forward model data result in much improved absorption feature shape matching, indicating a small spectral position reporting error by the monochromator. The shifts are a function of the diffraction grating used for the spectral measurements; estimated spectral position shift is on the order of 1% of total spectral bandpass for MAS channels. The atmospherically corrected SRF shape improves the results considerably and are being incorporated into the final MAS calibration for the SUCCESS data sets.

The March and June 1996 atmospherically corrected SRF showed spectral position discrepancies for Ports 3 and 4 of about 30 and 70 nm respectively. In order to answer the question of how to apply this discrepancy to the MAS SUCCESS data set, the MAS and well-calibrated HIS data sets have been compared for various flights during the experiment. The comparison for data early in the SUCCESS deployment on 13 April 1996 (Figure 4) shows that MAS-HIS biases are sharply reduced, especially for the spectrally sensitive MAS channels 34-36, 43, and 48-50 when using the June '96 SRF instead of the March '96 SRF. This is a strong indication that the June '96 SRF should be applied and the March '96 SRF ignored. Similar bias reduction was realized in a comparison of the MAS-HIS biases for the 3 May 1996 data flight (near the end of the SUCCESS experiment). Comparisons will be made for other SUCCESS days. Pending completion of the comparisons, the recommendation is that the MAS SUCCESS data set be processed for final calibration using the June '96 atmospherically corrected SRF.

HIRS Cloud Climatology

The HIRS CO2 cloud climatology now contains eight boreal winter (December - February) and eight boreal summer (June - August) seasons from June 1989 to May 1996. Cloud occurrence, height, and effective emissivity are determined with the CO_2 slicing technique that accounts for clouds partially filling the sensor field of view and semi-transparency of some clouds. More than 40% of the HIRS observations find cirrus clouds; their presence appears to be gradually increasing about one percent per year. This unprecedented high detection of cirrus clouds is supported by recent aircraft experiments during SUCCESS that found nearly continual presence of nearly invisible layers of small ice crystals mostly transparent near 10 microns but highly absorbing toward 12 microns. Comparisons with cloud studies conducted by ISCCP reveal similar trends from year to year, but the ISCCP cirrus detection is less than half that of HIRS. Comparisons with SAGE high cloud frequency distributions are quite good; global patterns are well correlated. A paper on this work was presented at the ninth International TOVS Study Conference held in Igls, Austria 20 - 26 February 1997. A paper has been written for the technical proceedings of that conference (Menzel et al., 1997).

GOES Biomass Burning Program

The following work on biomass burning complements some of our MODIS work but is funded under separate NASA (NAGW-3804) and NOAA contracts.

SCAR-B data analysis in the past quarter included reprocessing the daily multispectral GOES-8 imagery (at 11:45 UTC) collected during the SCAR-B field program (15 Aug.-15 Sept., 1995) with an updated version of the GOES-8 smoke/aerosol detection algorithm. The new algorithm uses single and multiband difference thresholds (including visible, 4, 11, and 12 micron data), solar zenith angle corrected albedo calculations, and solar and satellite viewing geometry in the process of distinguishing smoke/haze from multi-level clouds, low-level moisture, and sun glint. The revised algorithm shows significant improvements in identifying sun glint contamination and in locating smoke in northeastern Brazil where it is often difficult to separate smoke from low-level moisture in the Amazon. Additional work is needed to eliminate false positive identification of smoke in regions of thin cirrus clouds and along gradients between clear and cloud contaminated pixels.

Several options are being tested in version 2.0 of the GOES-8 ABBA to reduce the number of false positive ABBA fire observations in South America associated with sub-pixel solar reflectivity in the short-wave infrared window (4 micron) near local noon (1445 UTC) and sub-pixel cloud contamination. Preliminary analyses indicate that a more robust algorithm for determining background characteristics may help reduce false positive fire observations. A new technique is being developed and tested for cloud-clearing and background brightness temperature field characterization using a combination of a visible albedo threshold, single band thresholds in the 4 and 11 micron infrared windows, and a 4 minus 11 micron difference histogram approach.

The ABBA is also being modified for application in North America as part of a collaborative multi-sensor (GOES, POES, DMSP) early warning fire detection and assessment study coordinated by Chris Elvidge at NGDC. Initial versions of the GOES ABBA are being tested on fires in New Mexico (GOES-8) and Alaska (GOES-9) using half hourly data collected on 9-13 June 1996 in New Mexico and on 24 June 1996 in Alaska. The GOES-9 data collected over Alaska documents a number of fires between 60 and 70°N indicating the potential for GOES-9 fire detection and diurnal monitoring at northerly latitudes. The New Mexico data set provides a good example of the capabilities and limitations of fire detection in the southwestern US where enhanced solar reflectivity within 3 hours of local noon can result in numerous false positive fire observations. It is anticipated that a revised background characterization scheme will improve the capabilities of the GOES ABBA as an early warning wildfire detection tool throughout North America.

A sequence of 1-minute multispectral super rapid scan GOES-9 data collected over the Western US from 01:22 to 01:39 UTC on 16 August 1996 revealed the ability to detect rapid changes in fire characteristics from one image to the next with the GOES. Figure 5 shows time series of short- and long-wave infrared window observed (T4 and T11) and background (TB4 and TB11) brightness temperatures for 4 fires detected in the GOES-9 imagery. Fires B and C show relatively small changes in the observed fire and background characteristics throughout the time period. Fires A and D show little variation in background characteristics and the long-wave infrared window (11 micron) brightness temperature , but large variations in the short-wave infrared window (4 micron). The short-wave infrared window brightness temperature changes by as much as 8 °C in one minute, while the nearby background values remain fairly constant. This would indicate that for fires A and D the large variations in the observed brightness temperatures in the short-wave infrared window are due to changes in fire characteristics (e.g. size, intensity, etc.). This data set will be further analyzed with the revised GOES-9 ABBA.

PAPERS

Menzel, W. P., D. P. Wylie, K. I. Strabala, and R. Frey, 1997: Eight years of global cirrus cloud statistics using HIRS. Technical Proceedings of the ninth International TOVS Study Conference

Menzel, W.P., and E.M. Prins, 1996: Monitoring biomass burning with the new generation of geostationary satellites. In Biomass Burning and Global Change, Volume 1, edited by J.S. Levine, pp. 56-64, The MIT Press, Cambridge, MA.

Prins, E.M., and W.P. Menzel, 1996: Investigation of biomass burning and aerosol loading and transport utilizing geostationary satellite data. In Biomass Burning and Global Change, Volume 1, edited by J.S. Levine, pp. 65-72, The MIT Press, Cambridge, MA.

Strabala, K. S., S. A. Ackerman, C. C. Moeller, L. E. Gumley, R. A. Frey, J. Y. Li and W. P. Menzel, 1996: Cloud Properties Determined from MODIS Airborne Simulator (MAS) SUCCESS Observations. Paper accepted to the Third International Airborne Remote Sensing Conference and Exhibition to be held in Copenhagen, Denmark July 1-10, 1997.

MEETINGS

Dan LaPorte attended the Pre-environmental Review at Santa Barbara Remote Systems in California on 6-7 January.

Paul Menzel, Dan LaPorte and Chris Moeller attended the MODIS Thermal Infrared Calibration Team Meeting at the University of Miami on 9-10 January.

Elaine Prins attended the Conference on GIS and Remote Sensing Applications to Disaster Management in Greenbelt, MD on 14-15 January 1997 and presented a paper on the GOES-8 ABBA and future applications for early warning wildfire detection and monitoring in North America.

Paul Menzel chaired the EOS PM platform ATBD review in Columbia, MD on 11 - 13 March 1997.

Elaine Prins attended the Langley DAAC UWG (Distributed Active Archive Center Users Working Group) Meeting in Hampton, VA on 13-14 March 1997.

Elaine Prins attended a meeting on 17 March at NASA GSFC to discuss the direction of the NASA MTPE sponsored interdisciplinary science study to characterize aerosol forcing over the Atlantic Basin associated with urban/sulfate, Saharan dust, and biomass burning aerosols and CIMSS participation in this effort.

Table 1. WINCE Data Acquisition Summary

Date Flight No.	MAS	HIS	CLS	MIR	HSRL	AERI	Classonde	Other
28 Jan 97-041	1647-1921	1639-1656	1647-1921	1647-1921[1]	1718-1948	Continuous operation	1901	Nolin Snow L. Mendota
29 Jan 97-042	1630-1929	no data	1630-1929[N]	1630-1929[1]	2327-0052 1635-1959	"	1618, 1920	Nolin Snow L. Mendota
30 Jan 97-043	1724-1936	no data	1726-1936	1724-1936[1]	1638-1940	"	1740	
02 Feb 97-044	1633-2053	1618-2053	1632-2053	1618-2053[1]	1547-2200	"	1955	Bondville AERI
06 Feb 97-045	1750-2210	1742-2203	1801-2209	1742-2203[2]	1644-2326	"	2146	L. Mendota AERI
08 Feb 97-046	1636-2039	1622-2037	1635-2038	1622-2037[2]	1747-2045	"	1930	L. Mendota AERI; P.F. CO tower; T. L. DNR
09 Feb 97-047	1618-2002	no data	1639-1749	1618-2117[2]	1936-2223	"	2042	Hall in NH
11 Feb 97-048	0000-0300	2336-0258	0000-0256	0000-0300[1]	0021-0405	"		
12 Feb 97-049	1640-1959	no data	1640-1959	1640-1959[2]	1633-2016	"	1650, 1906	L. Mendota AERI; Hall WI
13 Feb 97-050	1633-2119	not flown	not flown	not flown	1510-2000	"	1700	

All Dates/Times in UTC

[1] Operated in Stare mode
[2] Operated in Scan mode
[N] Missing navigation data

Table 2. WINCE Science Objective Summary

Date Flight No.	Cloud Detection	Snow Detection	MAS/HIS Calibration	ADEOS Underflight	SSEC Overpass	GCIP (Bondville)	Park Falls CO	Other?
28 Jan 97-041	y	y		OCTS/img (CLR/CI) 1733	190530 clr			NOLIN SNOW instrument checkou
29 Jan 97-042	y	y			1927 ovc			bare ground to snow transition
30 Jan 97-043	y				1729 1803 1839 1912 1933 ovc			ice and water cloud over SSEC
02 Feb 97-044	Y	y		OCTS (OVC) 1710	2045 2052 (clr)	1954 2001 2007 2014 (CLR/CI)	y (ovc)	
06 Feb 97-045	Y	y	y	*	2205 (clr)			PC OVER HUDSO BAY
08 Feb 97-046		y	Y		2028 2036 (sct)		Y (CLR)	TROUT LAKE For McCoy
09 Feb 97-047	y	Y						Scele ag station
11 Feb 97-048	Y			*				NIGHT FLIGHT
12 Feb 97-049	y	Y		POLDER/ octs (CI) 1742	1946 1954 (CLR)			les, EO, snow emissivity
13 Feb 97-050		y		octs (ovc) 1657	~1642 (THIN CI)			Lake Tahoe; Wyoming snow

All Dates and Times in UTC. CAPITALIZED information indicates priority status.
* Underflight scrubbed due to delay in launch or early return of aircraft

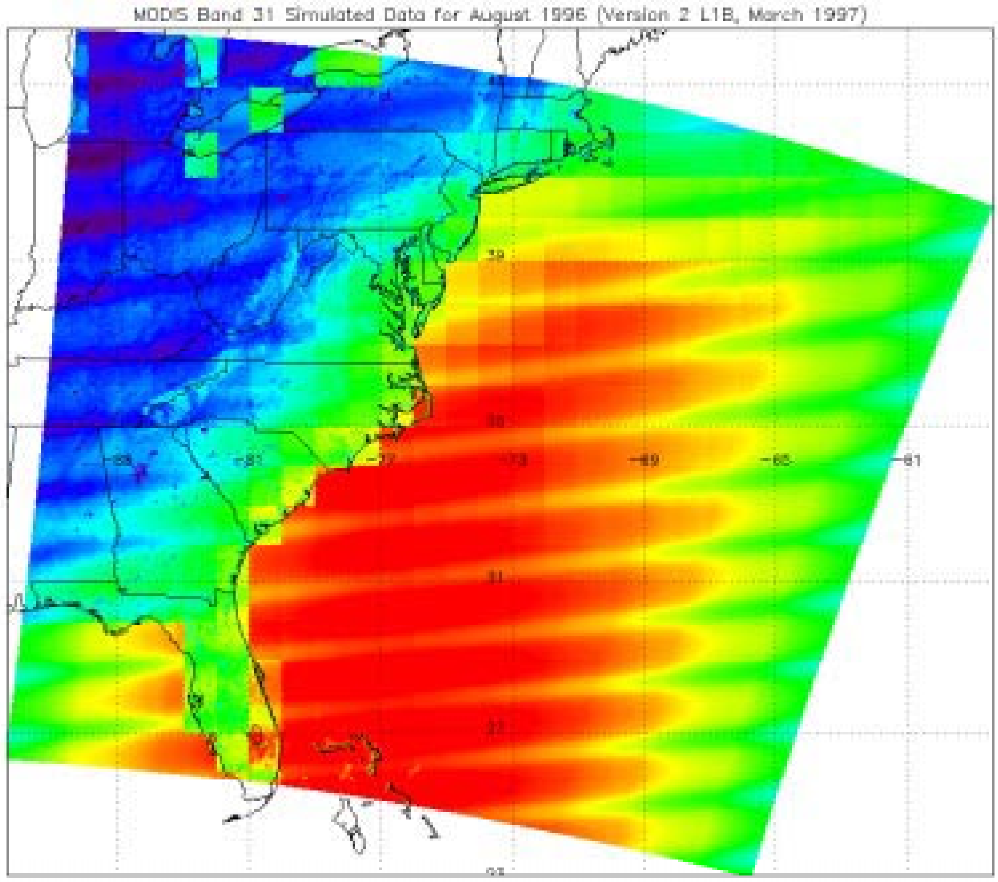
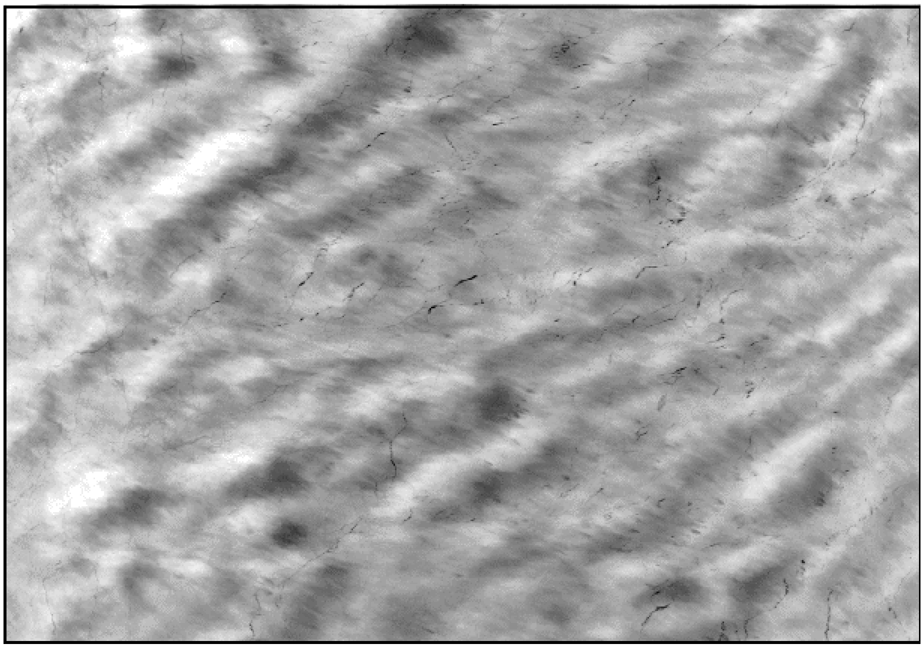


Figure 1. The image shows MODIS Band 31 extracted from the most recent (March 1997) MODIS Level 1B file format resampled to an isotropic Mercator projection. Latitude and longitude data for every 5th line and pixel is now stored in the MODIS 1km resolution HDF files, and this data was interpolated to the same resolution as the image data. Graphics are from IDL using UW developed software.



V I S I B L E (.56 microns)

T H E R M A L (11 microns)

Figure 2. MAS imagery over frozen Hudson Bay on 6 February 1997. Low transmissive clouds in the visible data (note cloud shadows) are almost invisible in the infrared (note prevalence of ice leads in the thermal data). MAS data from WINCE are being used to assess and improve MODIS cloud masking capability in difficult winter scene conditions such as is illustrated above.

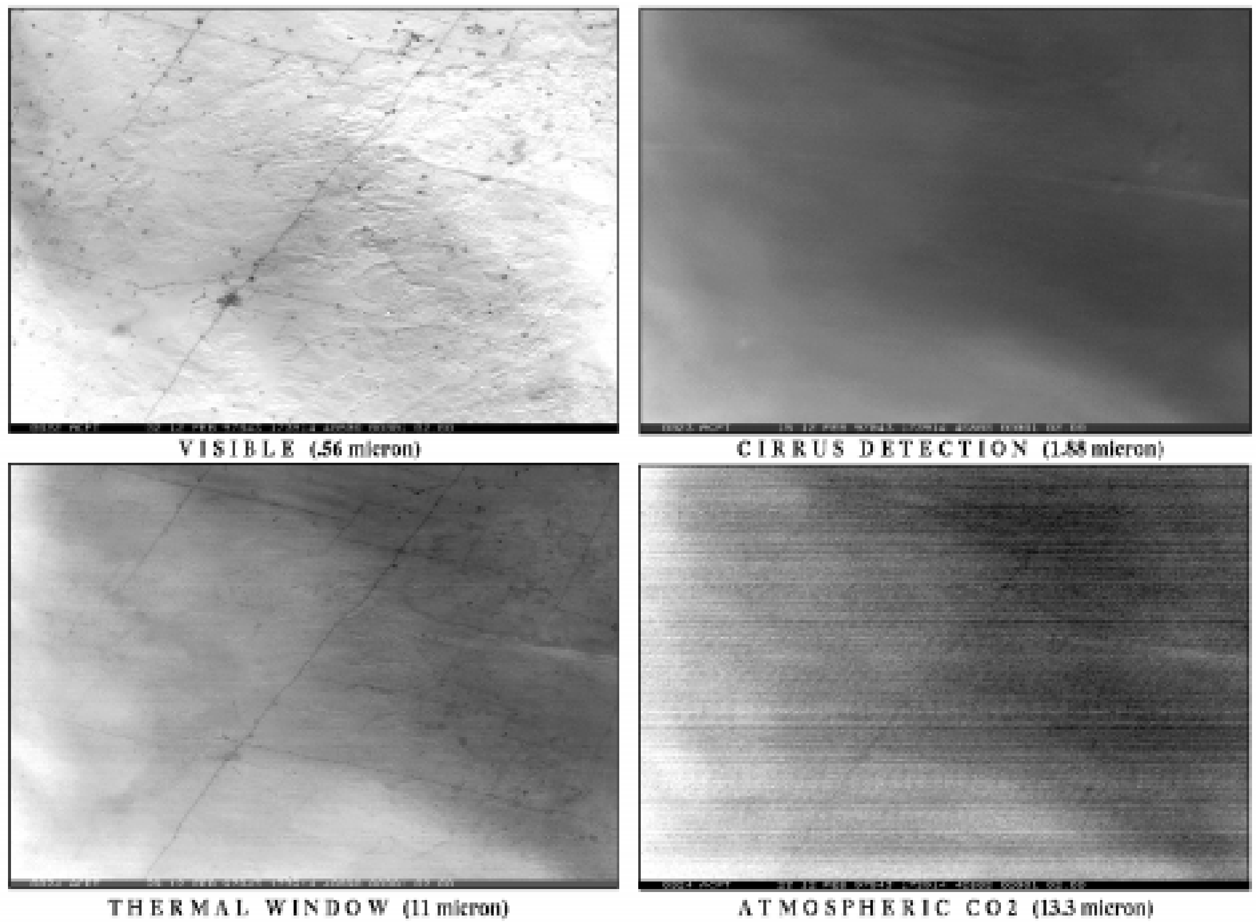


Figure 3. MAS imagery of thin cirrus scenes over snow-covered North Dakota on 12 Feb 1997. MAS (and MODIS) has a cirrus detection channel at 1.88 microns (MODIS 1.38 microns) which will be invaluable during daylight conditions for finding thin cirrus. At night, MAS (and MODIS) must rely on spectral tests using thermal bands such as CO2 sensitive channels to detect cirrus.

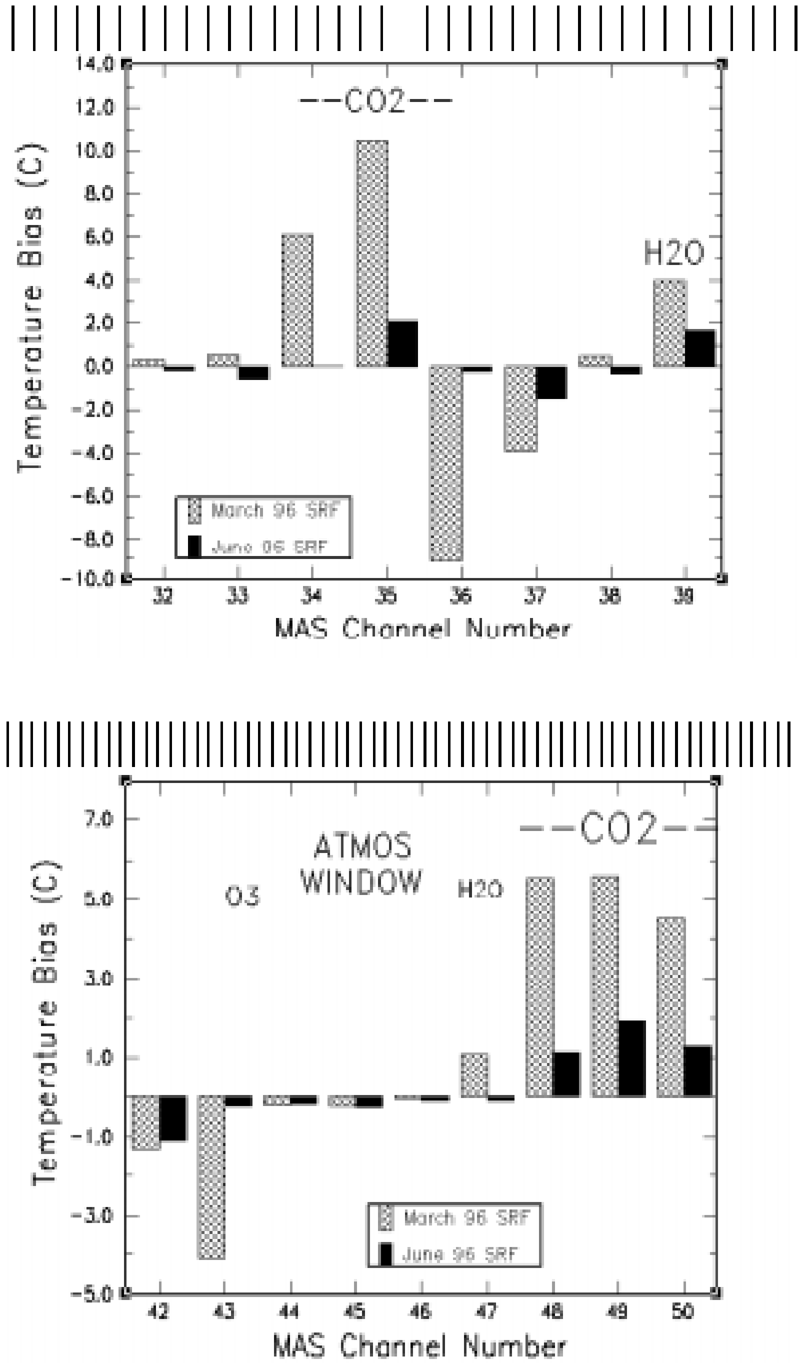


Figure 4. MAS-HIS biases on 13 April 1996 using March '96 MAS spectral response (SRF) compared to June '96 SRF. Biases are strongly reduced using the June '96 SRF indicating that during SUCCESS, the MAS spectral characteristics were closely matched by the June '96 SRF.

GOES–9 Super Rapid Scan Obervations of Fires in the Western US
Date: 16–August–1996 Time: 01:22 – 01:39 UTC

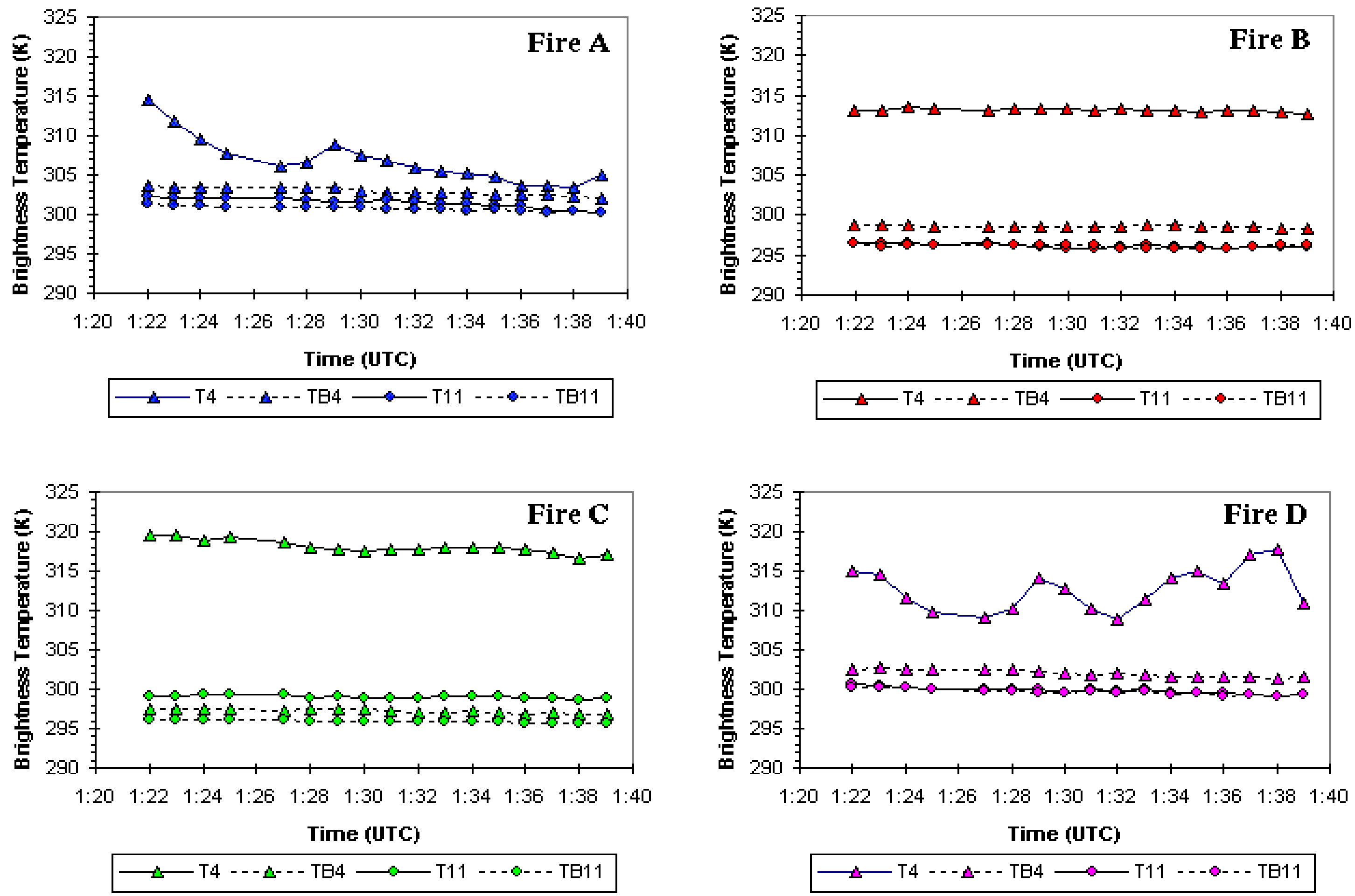


Figure 5. Time sequence of observations from GOES-9 for four different fires over the Western United States.